Status of GEM prototype design for the EIC FT

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Common GEM foil design

- Have been finished with Altium in the summer, foil dimensions (active area, trapezoid shape) are: **43 mm** at small end, **523 mm** at large end and **903 mm** long, **30.1 degrees** opening angle. It is a common design suitable for FIT, Uva and TU, who are using different assembly techniques.

- The design has been passed to CERN (Rui's group) by Kondo, there it can be read by UCam without issue. CERN people (Bertrand Mehl) added GEM holes and made very slight changes.

- Gerber files have been created, I don't see any problem, production could be launched.

Chamber assembly idea in FIT group

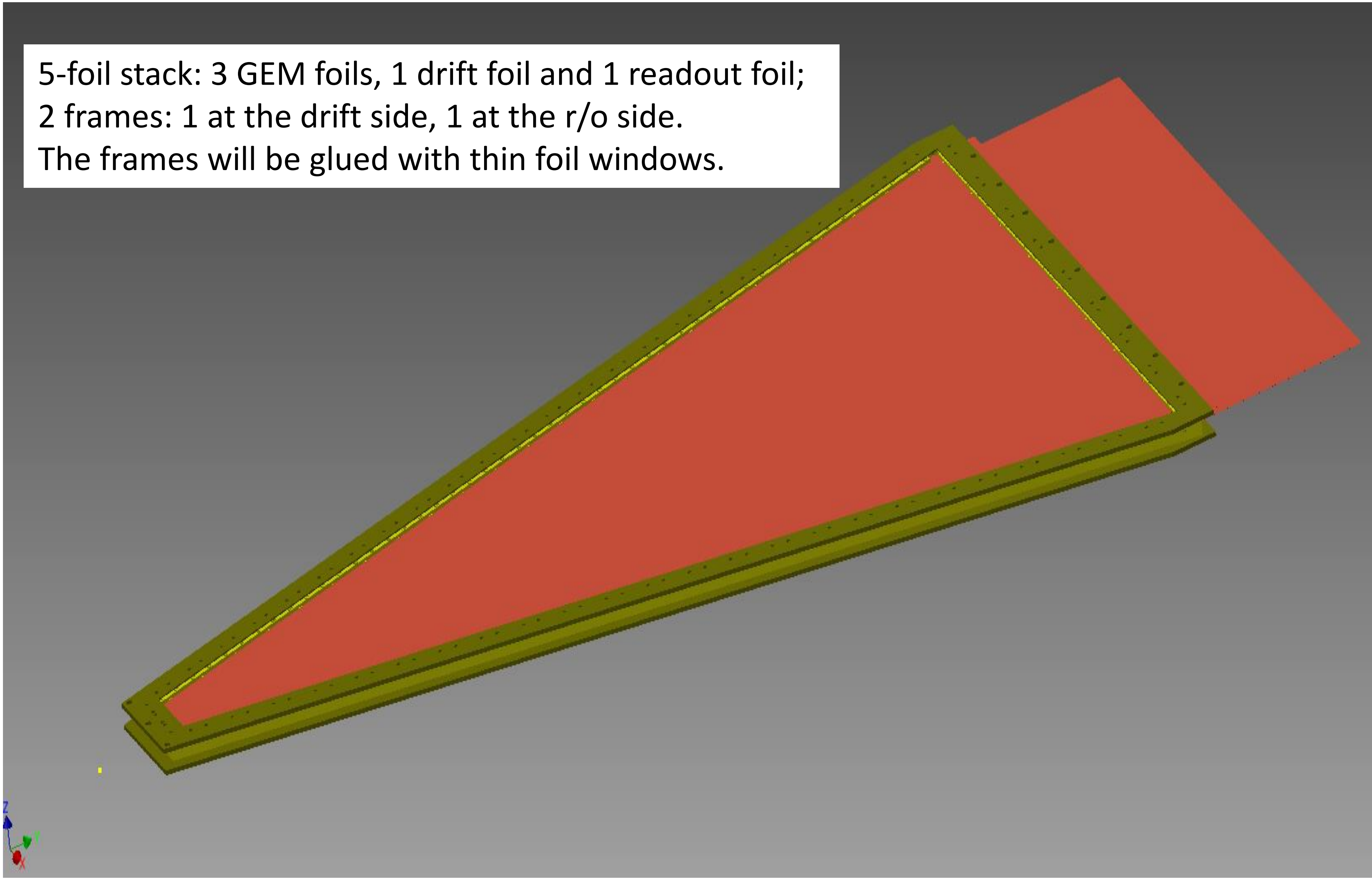
- The mechanical stretching method used by the CMS GEM collaboration makes a 3-foil GEM stack, stretches the GEM stack to a solid drift board and close the chamber with a solid readout board. The solid drift board and readout board, made of PCB material, will increase radiation length and hence increase Multiple Coulomb Scattering (MCS) to hadrons.

- Consequently, we propose to make a 5-foil GEM stack: 3 GEM foils, 1 drift foil and 1 readout foil. The GEM stack will be then stretched to a frame, and another frame will be used to close the chamber. The two frames have thin windows (100um Mylar foil, e.g.) for gas sealing.

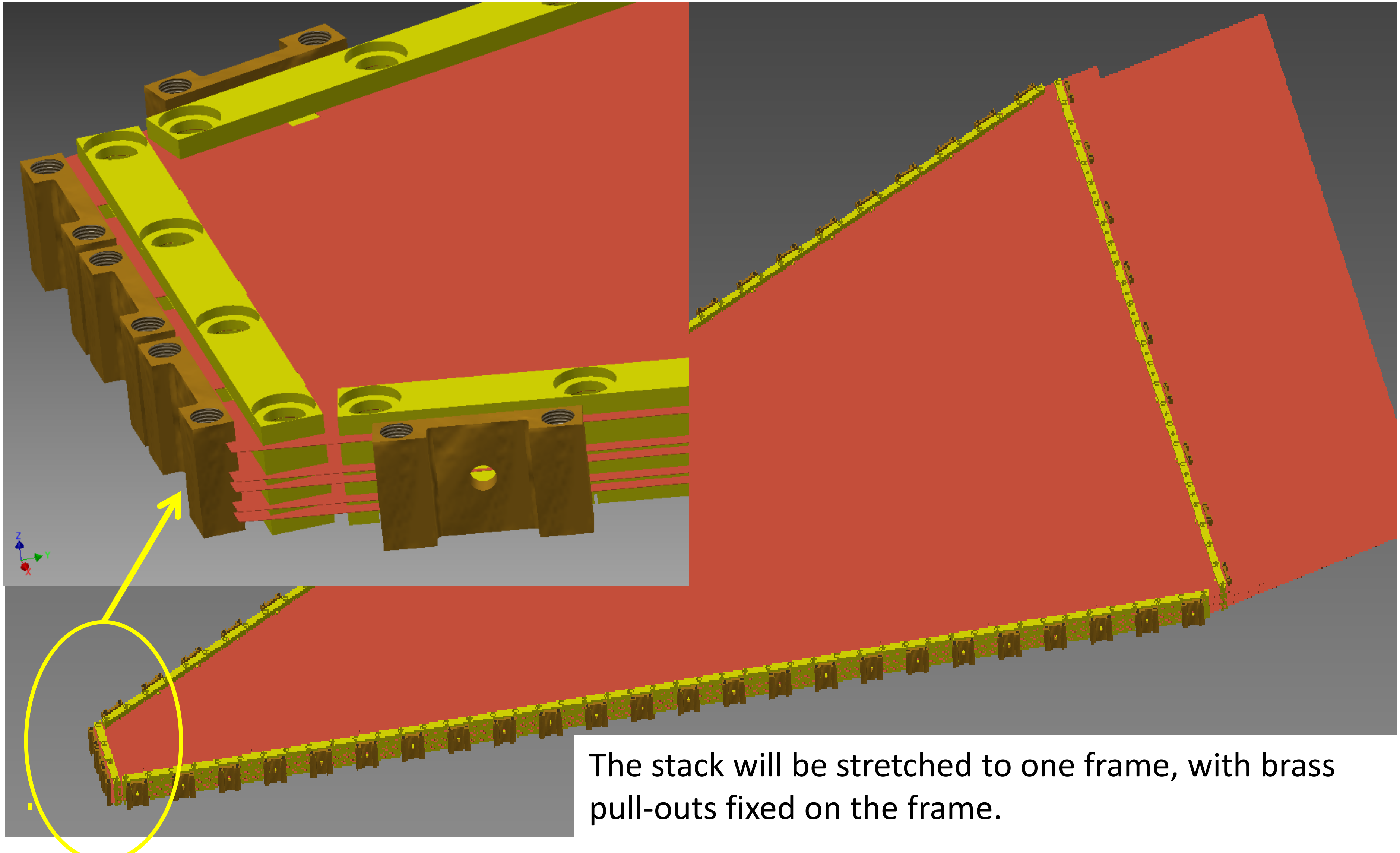
- For the frames, normal PCB material is considered. However, the strength could not be enough for stretching, so we also want to investigate other material possibilities, e.g., carbon fiber frames.

- The frames are designed in Autodesk Inventor, most of the parts are designed as well.

Chamber assembly idea in FIT group



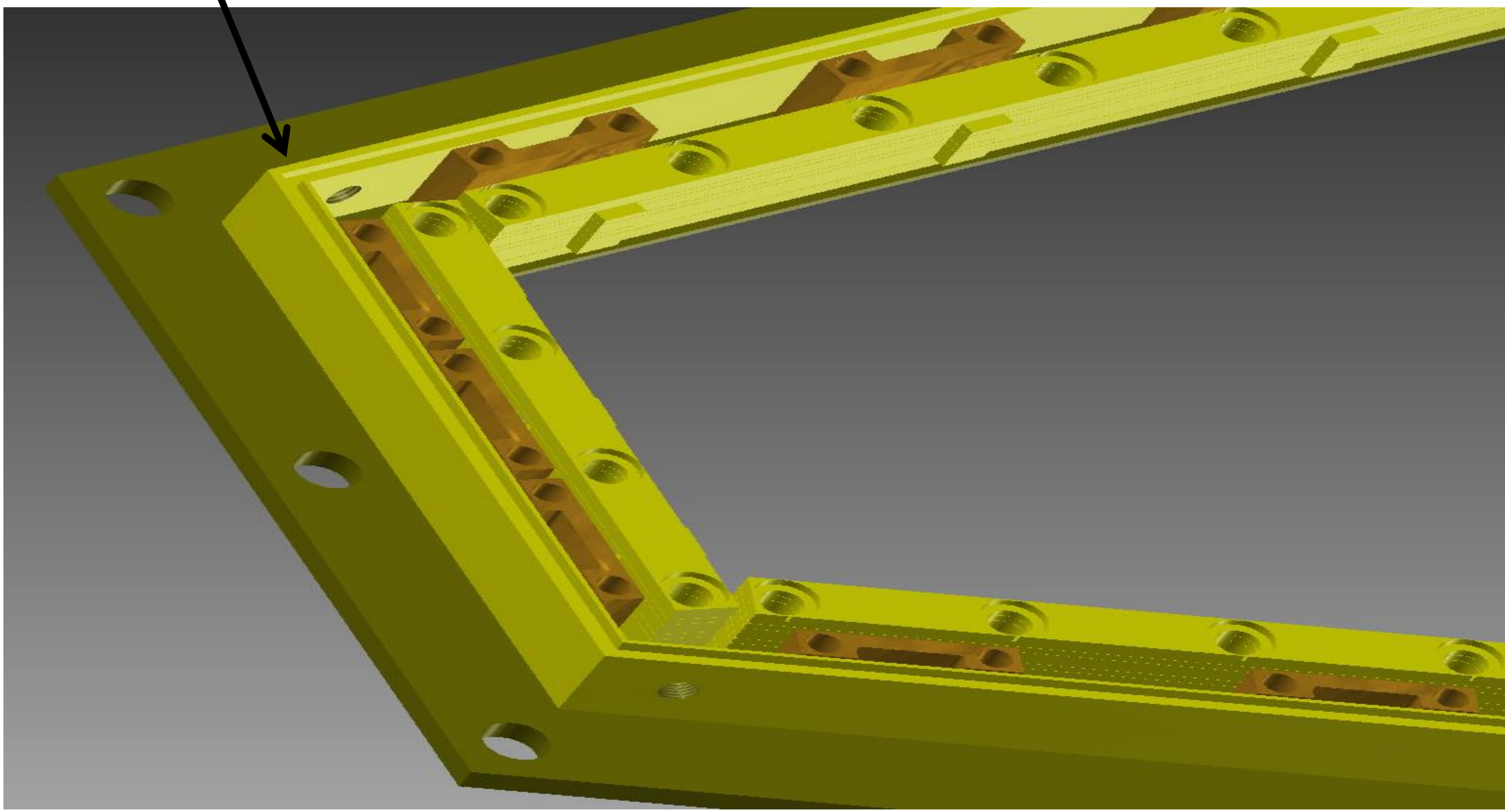
Chamber assembly idea in FIT group



The stack will be stretched to one frame, with brass pull-outs fixed on the frame.

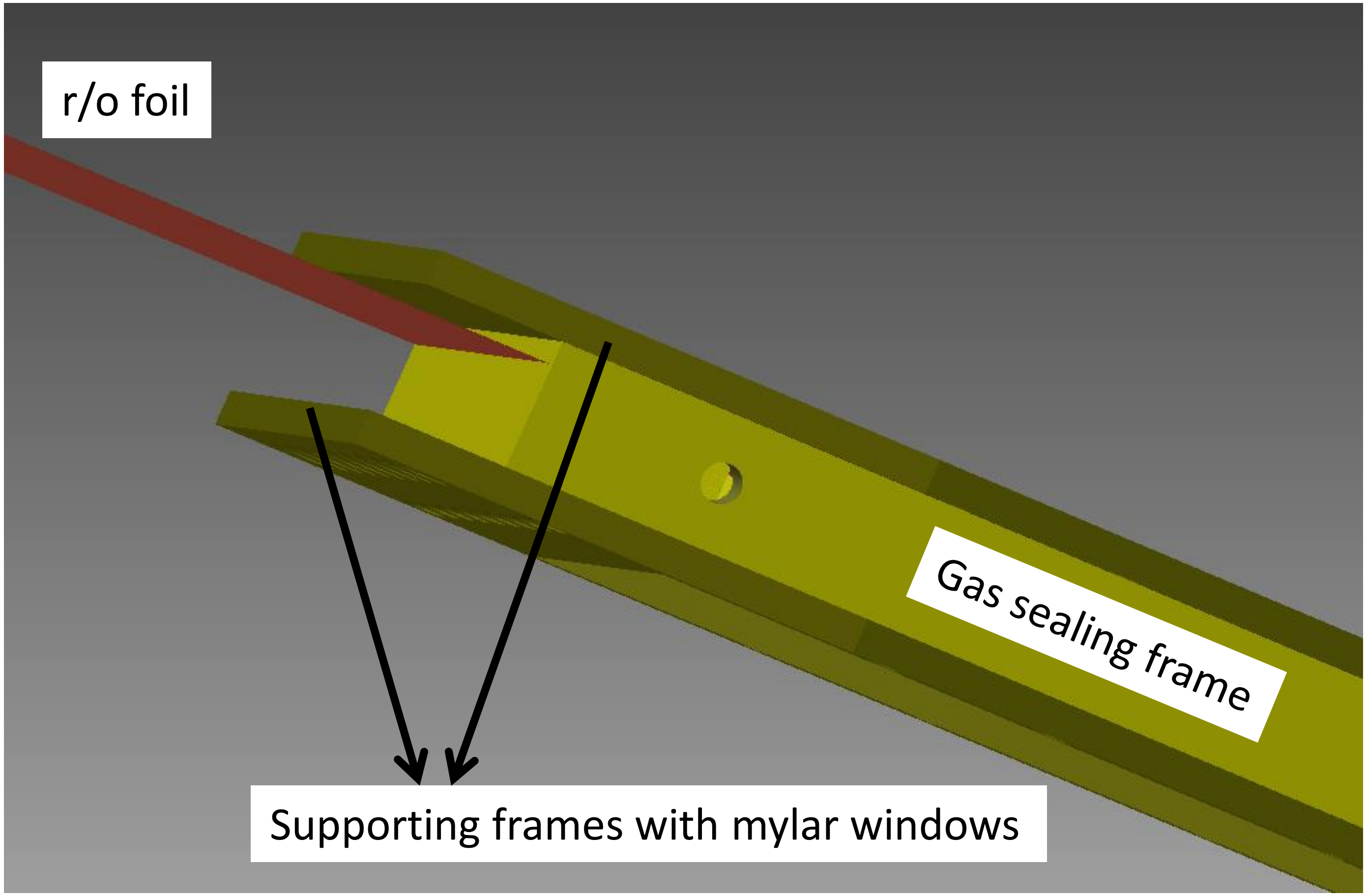
Chamber assembly idea in FIT group

One more frame, with groove for O-ring, is used to close the chamber



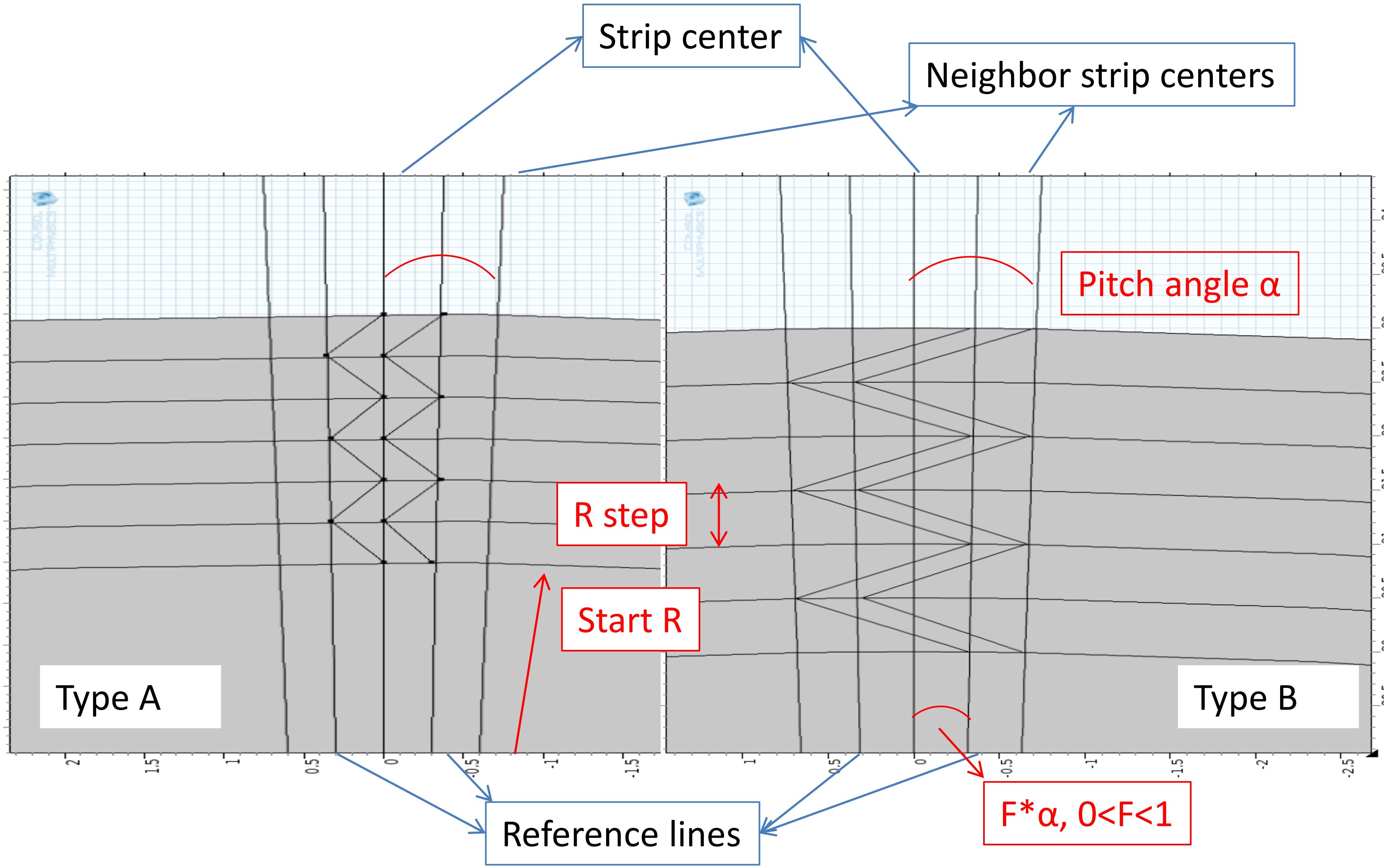
Chamber assembly idea in FIT group

One challenge: the stretching method requires cutting off the borders of GEM foils, so that a chamber can be closed by the frames (and that is why we have put HV pads on GEM foils and bring the HV connection through springs fixed on drift frame).
Now, we have to bring one side (the large end) of the r/o foil out of the frame. Current solution: the r/o foil is expected to be glued on the support frame, O-ring on the gas sealing frame will be touching the r/o foil



Readout foil design

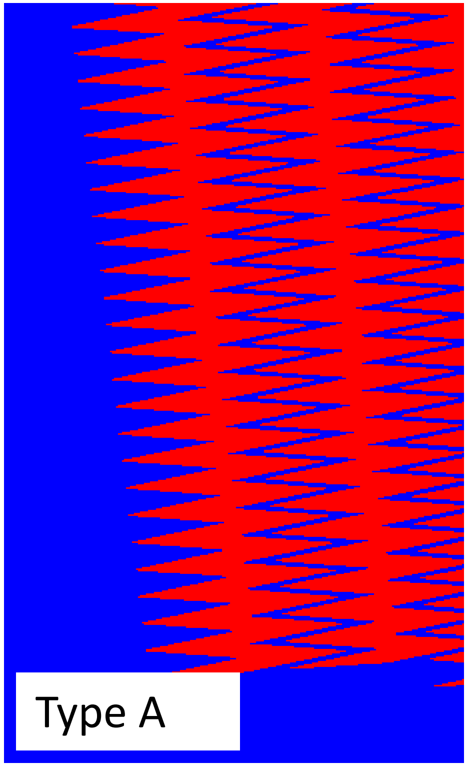
Radial Zigzag Pattern: **4 parameters** can define the zigzag strips .

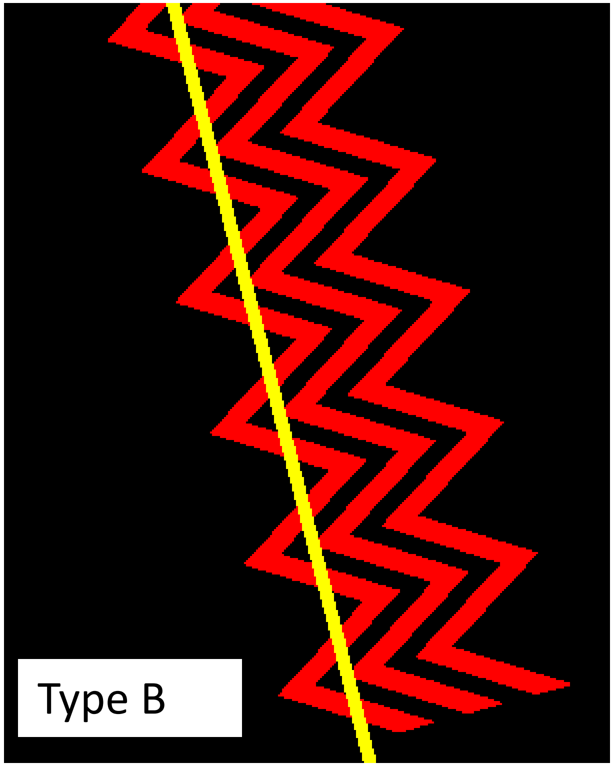


In type A, a zigzag strip is limited in the two reference lines, while in type B, a zigzag strip is limited in the two neighbor strips.

Readout foil design

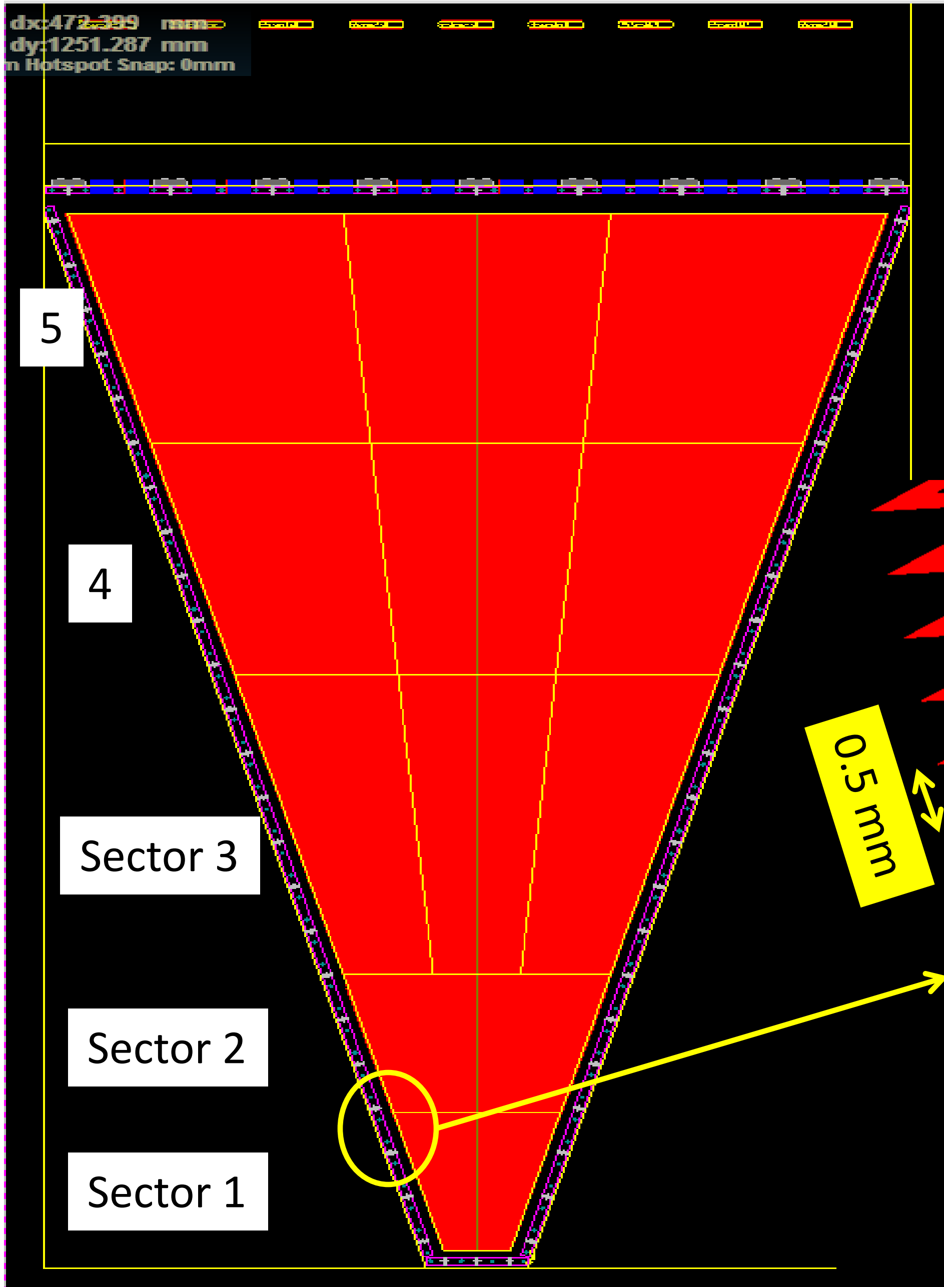
Radial Zigzag Pattern: **4 parameters** can define the zigzag strips .





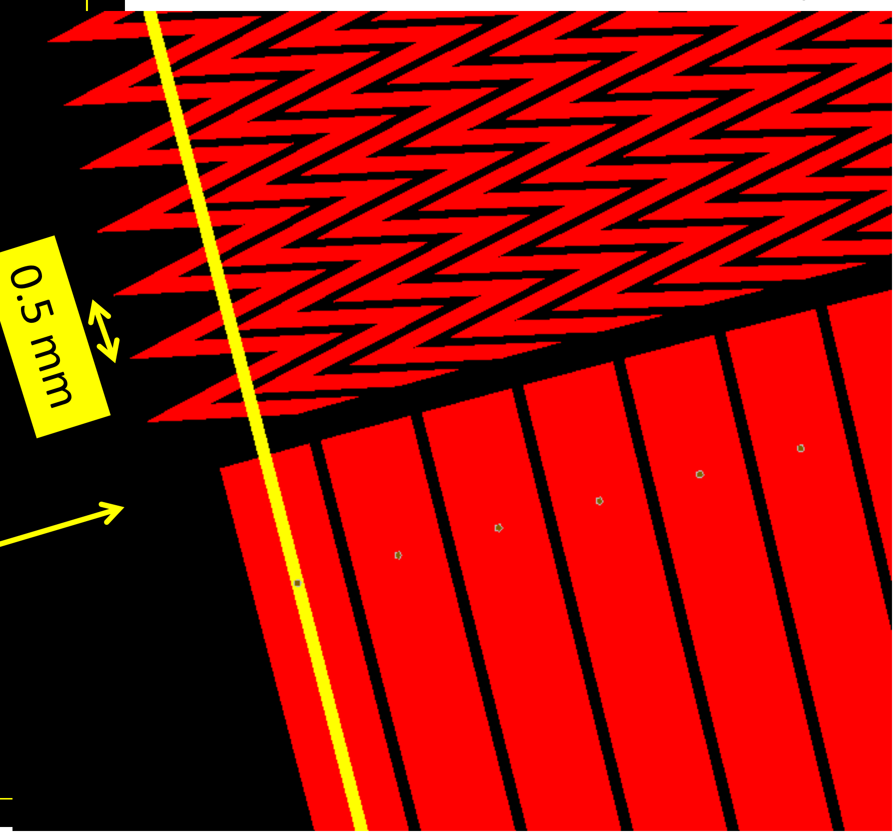
- Type A, 50% overlap pattern (as to Alexander's model) has been used in the last prototype.
- Type B, the 100% overlap pattern (each strip tip goes to the center of its neighbor strips), is to be used for the new prototype, with the hope of getting better resolution.

Readout foil design

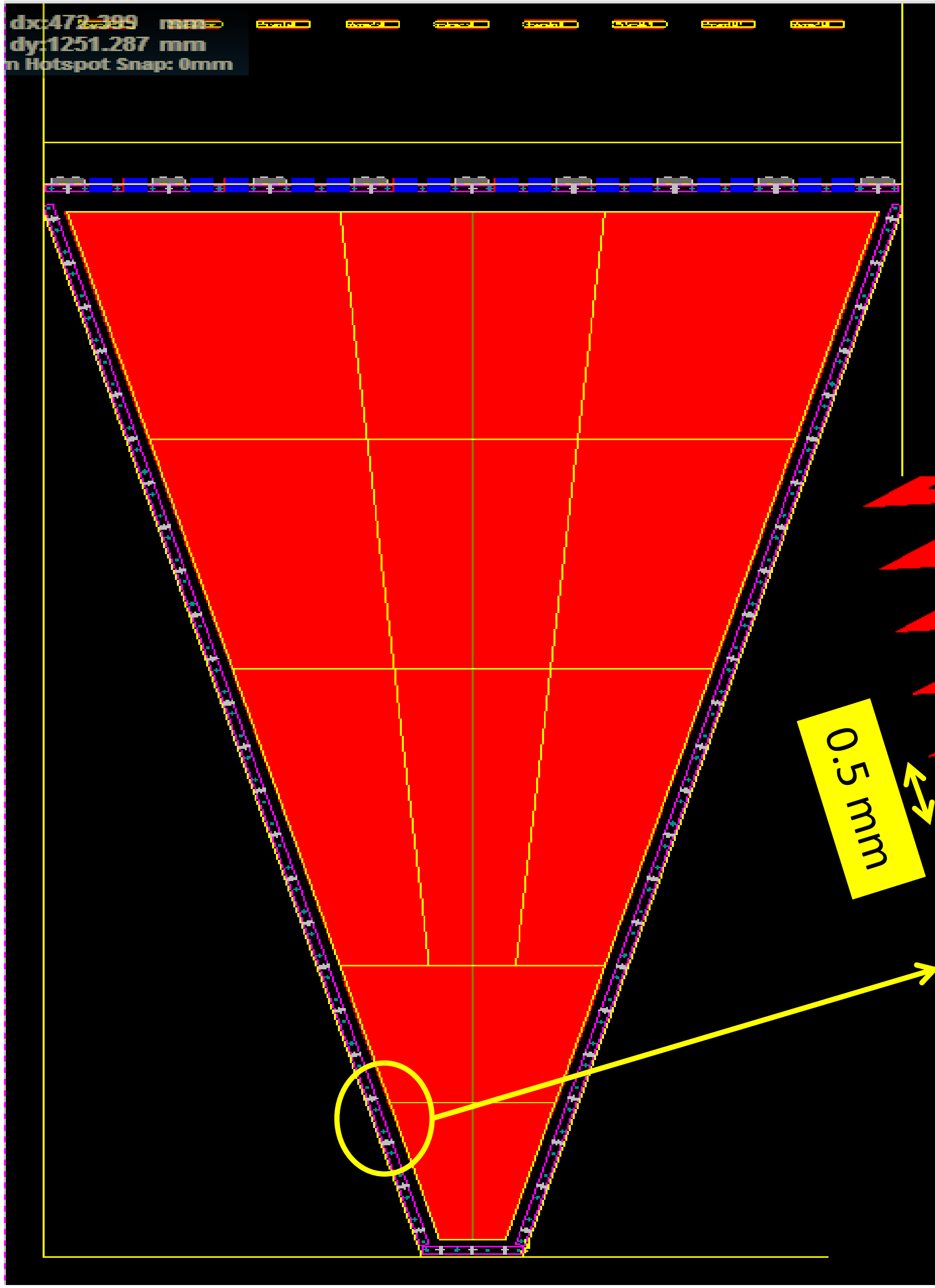


We decide to divide the readout region to 5 sectors:

Sector 1, the innermost sector will have 128 straight strips of length ~12 cm (1 APV to read out). Angle pitch is 4.14 mrad; strip width 0.25 mm -- 0.73 mm; strips end at the same R coordinate (on an arc).

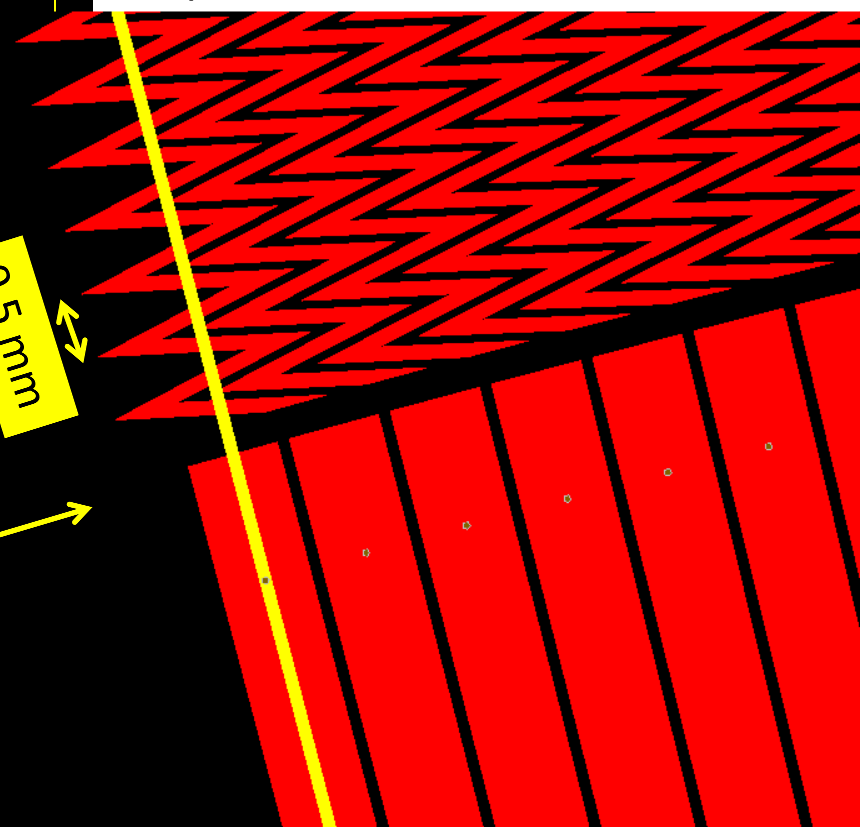


Readout foil design

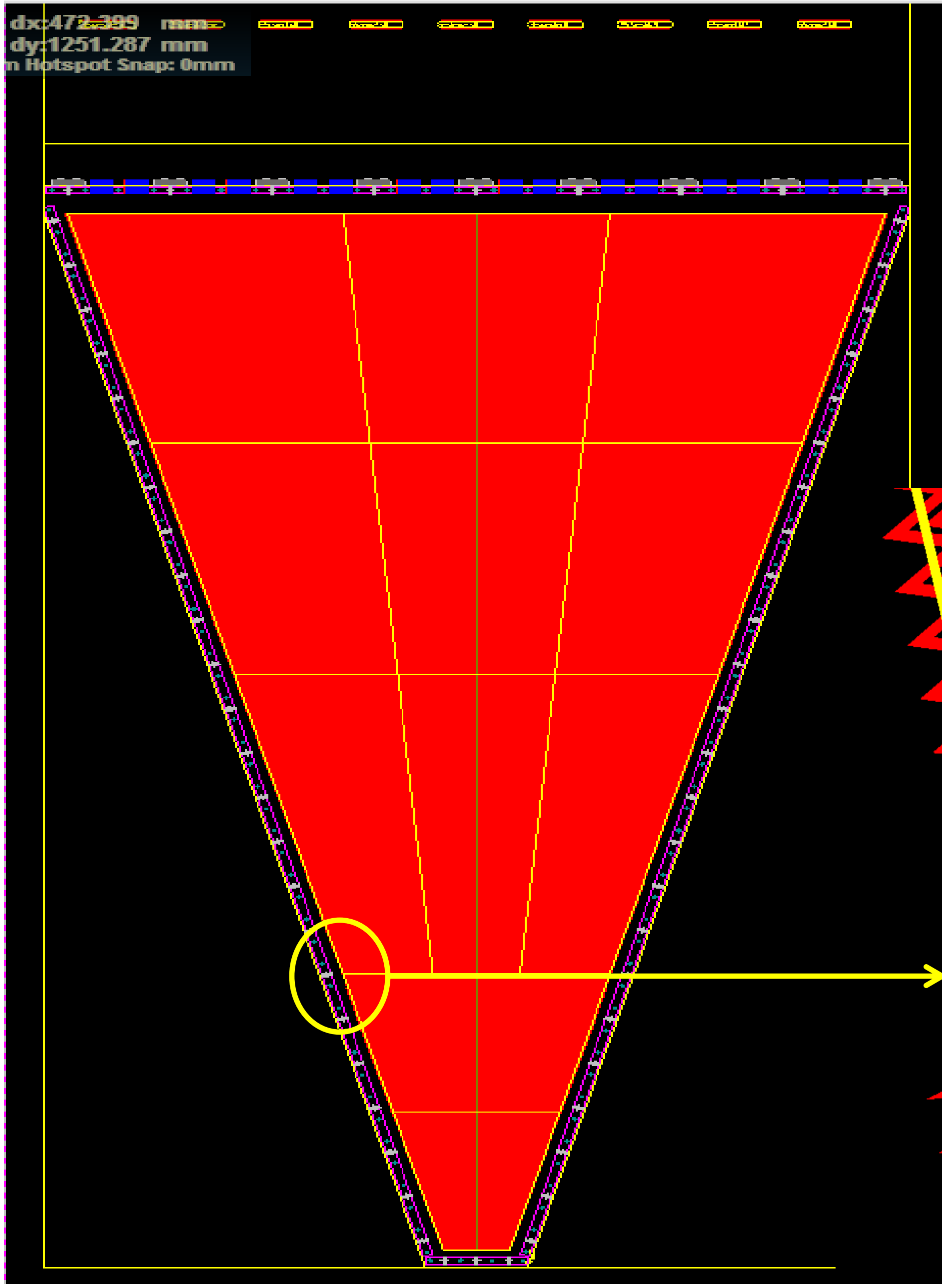


We decide to divide the readout region to 5 sectors:

Sector 2, 128 zigzag strips of length ~12 cm (1 APV to read out). Angle pitch is 4.14 mrad; copper width 0.1 mm everywhere (almost); gap between strips ~60um. Strips start and end on two arcs.

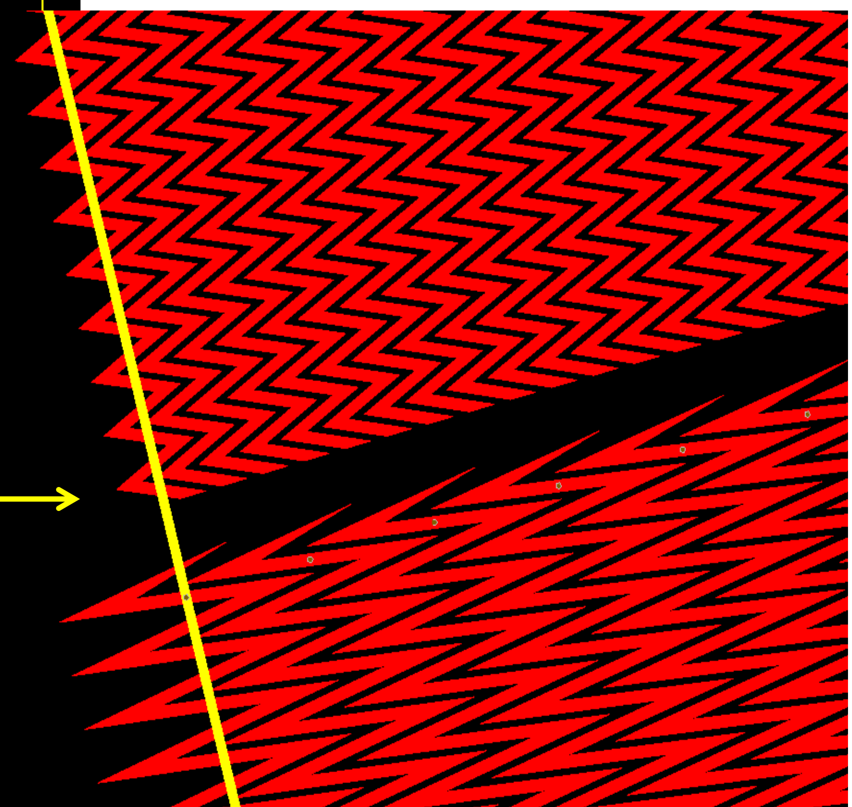


Readout foil design



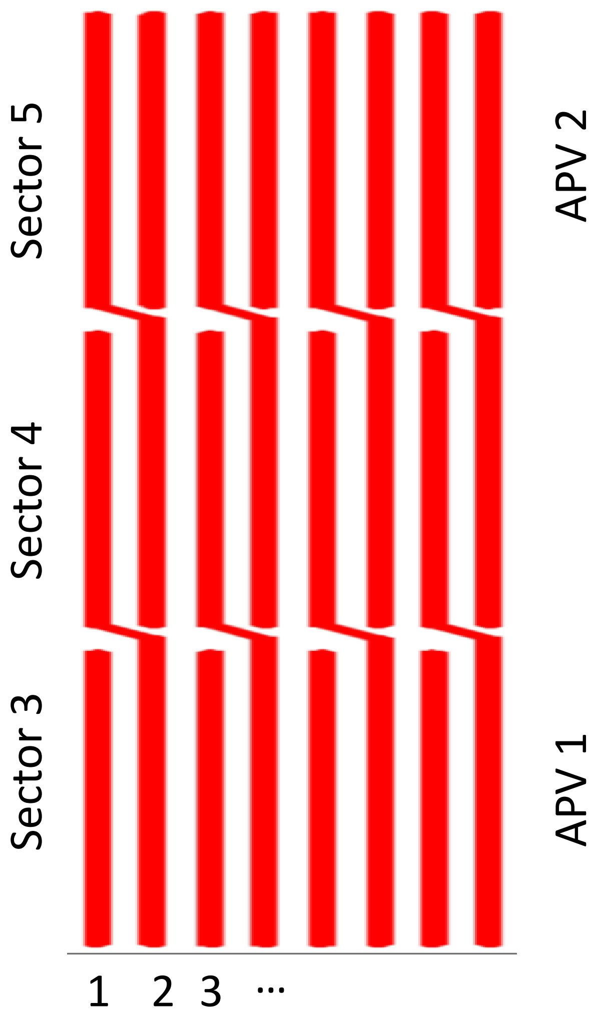
We decide to divide the readout region to 5 sectors:

Sectors 3,4 and 5, 384 zigzag strips of length ~22 cm. Angle pitch is 1.37 mrad (same pitch as the previous prototype); copper width 0.1 mm everywhere (almost); gap between strips ~60um.



Readout foil design

A new strategy (odd-even game) to reduce number of electronic channels for sectors 3,4 and 5: connect even strips in sector 3 to odd strips in sector 4, and connect even strips in sector 4 to odd strips in sector 5, so no APV is needed for sector 4.

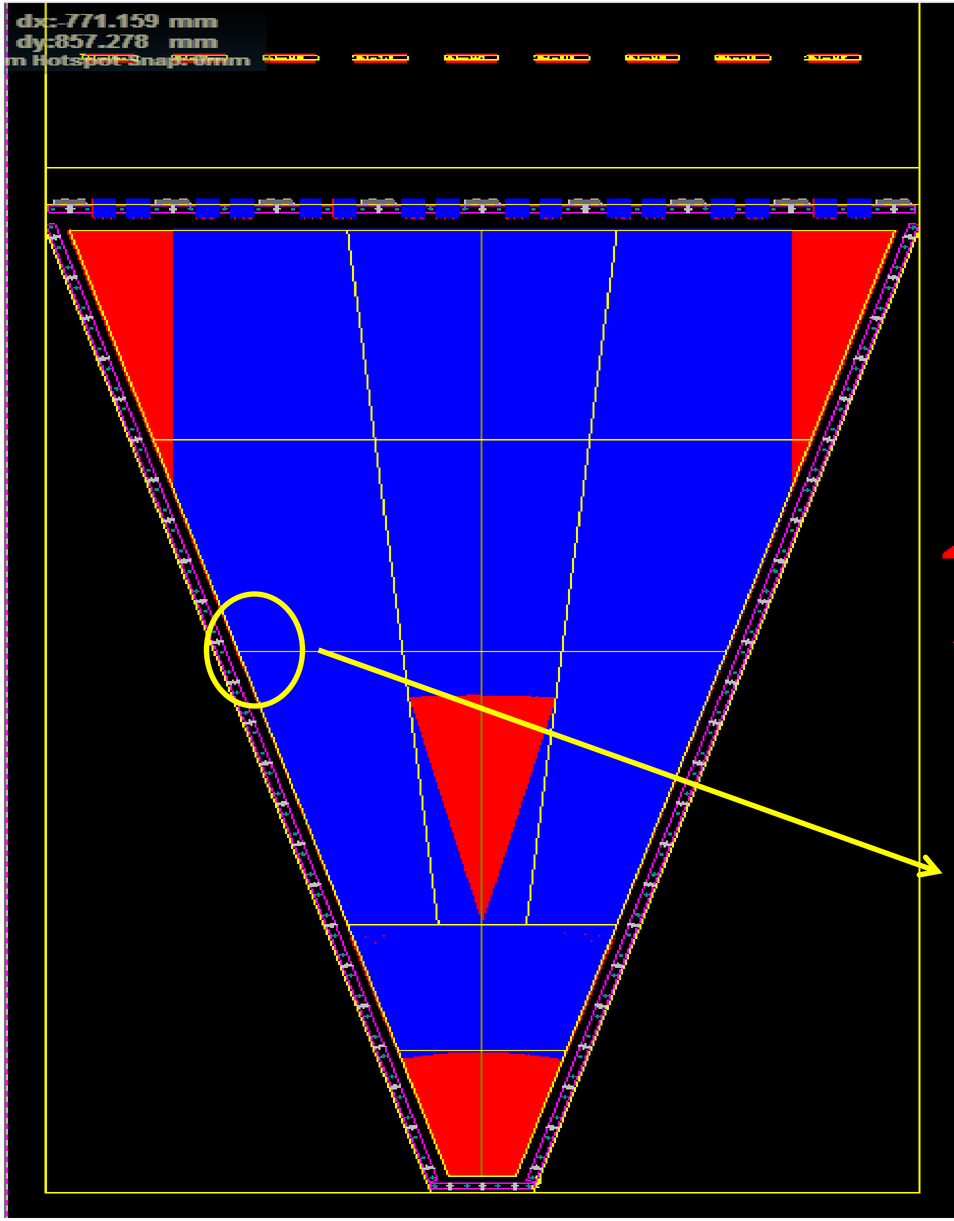


Signal modes:
(1) Single hit in sector 3 (or 5), only APV 1 (or 2) has signal, could be even and/or odd channels;
(2) Single hit in sector 4, both APV 1 and APV 2 have signals, and must even channel in APV 1 + odd channel in APV 2.
(3) Single hit in between sector 3 and 4 (or between sector 4 and 5) can be distinguished, e.g., even and odd channels in APV 1 + odd channel in APV 2.
(4) Hits with strip multiplicity = 1 can not be distinguished.
(5) Multiple hits can not be distinguished. However, one can know a multiple-hit event happens when odd channel in APV 1 + some channel in APV 2, or even channel in APV 2 + some channel in APV 1.

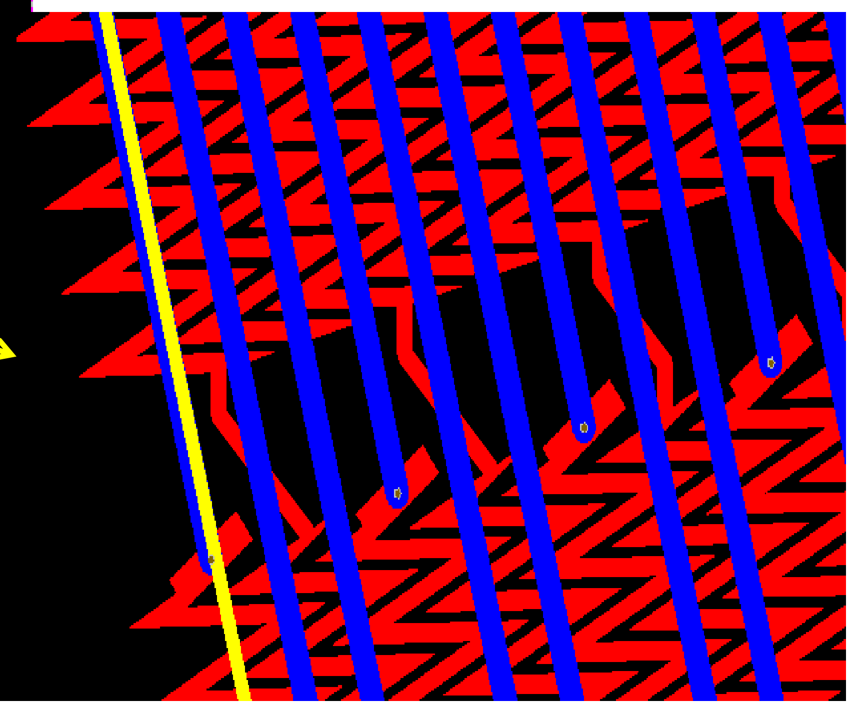
Readout foil design

- Since sectors 3, 4 and 5 have 128*3=384 strips each, for the 128 strips in the center of each sector, we plan to use 1 APV for each sector; for the left and right sides, we play the odd-even game so 2 APVs for each side. A total of 7 (APVs) is planned for the three sectors;
- Plus 1 APVs for sector 1 and 1 APV for sector 1, a total of 9 APVs (1152 channels) are needed to read out signals from the detector.
- A challenge is then to route out all the strips to Panasonic connectors. Vias, or vias substituent solution is necessary, if we consider only a 2-layer design for the readout.

Readout foil design



Traces bringing strips to the top region have been arranged, they need to be brought to Panasonic connectors. I am still working/thinking …



Summary

- Common GEM foil design is done, before we launch its production, we'd like to invite you to take a look at the final design (gerber files can be sent to you if agreed) and we welcome comments and suggestions.

- The FIT group is making some changes to the CMS mechanical stretching technique, in order to reduce material in the fiducial detector area. We'll investigate new materials for the support frames.

- The readout design is also challenging. Zigzag structure is (kind of) optimized, so we hope better resolution can be achieved.

Thanks!

Back up

Parallel Zigzag Pattern Parameters: